SECTION 23 00 00_HVAC DESIGN GUIDELINES

I. Purpose

The University of Delaware is a community of diversified organizations that work interactively to accomplish a common set of goals. The HVAC systems are provided as a tool to help the University community meet these goals. The intent of the HVAC Design Guidelines is to assist the HVAC design consultant to provide design that will within reason accommodate the needs of the various user groups within the University community.

These guidelines shall assist the consulting engineer meet the following University needs:

Occupant Comfort: The University is committed to providing a pleasant working and educational experience on the Newark Campus. These guidelines shall set the minimum requirements for indoor environmental comfort. It is the responsibility of the HVAC design firm to apply these guidelines in a way so that the University can provide a pleasant work place and educational experience.

Health and Safety: The University is committed to the health and safety of its entire community. The HVAC systems provide a significant role in insuring the safety of the University's built environment. These guidelines will determine the minimum requirements necessary to insure a safe and healthy campus. It is the responsibility of the HVAC design firm to apply these guidelines in a way so that the University can provide a safe and healthy campus.

Energy Efficiency: The University of Delaware is committed to reduce both the emissions generated and energy costs to run the Newark campus. HVAC systems consume a large percentage of the energy required by the Newark Campus. These guidelines are intended to assist the HVAC design firm incorporate energy efficiency in the HVAC design. It is the responsibility of the HVAC design firm to apply these guidelines in a way so that energy use is minimized.

Maintenance: In order to meet the University's occupant comfort, health and safety and energy efficiency goals, the HVAC systems must be maintained. Often time's maintenance is not considered within the HVAC system design. This often results in HVAC systems that are difficult to impossible to maintain. HVAC systems will often fall into a state of disrepair. These guidelines will provide the minimum maintenance requirements. It is the responsibility of the HVAC design firm to apply these guidelines to insure maintainability of the HVAC systems.

Construction: HVAC systems that are difficult and expensive to construct compromises the University's comfort, health and safety, energy efficiency and maintenance goals. Often time's construction is not considered within the HVAC system design. This results in HVAC systems that are difficult and expensive to construct. In addition poorly constructed HVAC systems result in inefficient energy use and compromises health and safety. These guidelines will provide the minimum construction requirements. It is the responsibility of the HVAC design firm to apply these guidelines to insure construction of the HVAC systems.

II. Campus Heating and Cooling Districts

The University of Delaware operates campus wide heating and cooling districts at all three (Central, South and Laird) Newark campuses. The districts provides the majority of the required heating and cooling capacity to meet seasonal demands.

Central Campus Heating District: Central Campus heating is supplied by a central boiler plant located in the central utility plant. The boiler plant generates 45 psig steam and distributes the steam via underground piping to the various buildings on the district. The steam is reduced to 15psig at the building level and is used by heat exchangers to produce heating hot water for distribution to heating coils. The steam is also used via heat exchangers to produce clean steam that is used for building humidification during the heating season. Steam condensate is recovered at the building level and is returned via steam driven pumps to the central utility plant.

Central Campus Cooling District: The Central Campus cooling district is composed of three chilled water plants: Central Utility Plant, East Central Utility Plant, and Ewing Utility Plant. All chilled water plants feed a common chilled water district. The chilled water is distributed via an underground chilled water piping system to the various buildings on the district. The chilled water is used to cool and dehumidify during the cooling season. When process chilled water is required a separate heat exchanger is supplied to decouple the process cooling from the chilled water district. Chilled water is recovered and returned through the district to the chilled water plants.

South Campus Heating District: South Campus heating is supplied by a boiler plant located in Worrilow Hall. The boiler plant generates 45 psig steam and distributes the steam via underground piping to Worrilow Hall, Townsend Hall and the Greenhouses. The steam is reduced to 15psig at the building level and is used by heat exchangers to produce heating hot water for distribution to heating coils. The steam is also used via heat exchangers to produce clean steam that is used for building humidification during the heating season. Steam condensate is recovered at the building level and is returned via steam driven pumps to the Worrilow utility plant.

South Campus Cooling District: South Campus cooling is supplied by a chiller plant located in Worrilow Hall. The South Campus chilled water district includes Townsend and Worrilow Halls. The chilled water is distributed via underground chilled water piping. The chilled water is used to cool and dehumidify during the cooling season. When process chilled water is required a separate heat exchanger is supplied to decouple the process cooling from the chilled water district. Chilled water is recovered and returned through the district to the chilled water plant.

Laird Campus Heating District: Laird Campus heating is supplied by a central boiler plant located in the Pencader complex. The boiler plant generates 200 degrees Fahrenheit heating water and distributes the heating water via underground piping to the various buildings on the district. Heating water is recovered and returned through the district to the Pencader boiler plant.

Laird Campus Cooling District: Laird Campus cooling is supplied by a central chiller plant located in the Pencader complex. The chilled water is distributed via underground chilled water piping. The chilled water is used to cool and dehumidify during the cooling season. Chilled water is recovered and returned through the district to the chilled water plant.

III. Code Compliance

It is the requirement of the consulting engineer to verify all HVAC systems designed or modified are in compliance with all applicable codes. The consulting engineer will conduct a code analysis to determine all applicable codes and document the impact to the design.

IV. Load Calculations and Energy Modeling

Modeling Software: All new and renovated buildings shall have load calculations performed and an energy model created. Load calculations and energy modeling must be performed via the following software:

Carrier HAP
DOE Equest
Elite CHVAC
Energy Soft EnergyPro
Trane Trace 700

The consulting engineer must have all necessary up to date licenses for the software. Designer or engineer performing calculations must be trained and certified on the software by the software developer or an authorized agent.

Building Energy Optimization: It is the responsibility of the consulting engineer to maximize energy efficiency The consulting engineer shall perform calculations and build the energy model that will maximize the efficiency of all elements of the building. This shall include all plumbing, lighting and building envelope. The HVAC engineer shall use the energy model to provide advice on all elements of the building design to all other design disciplines. In particular the following elements shall be addressed in the energy model:

Domestic Water Heating Options: Identify most efficient way to generate domestic hot water
Lighting Options: Including occupancy controls, day light harvesting and fixture types
Windows, Skylights & Clerestories: Detail effects on energy use and where they are best used
Building Insulation: Suggest optimize thickness of insulation
Roofs: Explore effects of different roofing systems including vegetative roofs
Shading: Determine where to apply shading via window treatment or exterior plantings
Orientation: Detail the effects of building orientation on building use

Assumptions: Often when load calculations and energy models are started assumptions (room occupancies, lighting intensity, insulation levels and plug loads…etc.) are made to facilitate the initial building of the model. These assumptions may be necessary to provide data necessary for the initial cost estimate or to determine the magnitude of the project. These assumptions must be detailed and communicated to the project team. The assumptions must never be carried into the final model. It is the responsibility of the consulting engineer to replace the assumed values with accurate data. The consulting engineer will certify that all data within the model is accurate.

Future Loads: Final calculations may have assumptions for future loads. These assumptions must be detailed and communicated to the project team.

Pay Back Formulas: When calculating payback for energy savings on a project, it is important to include both the savings and costs throughout the life cycle of the building and its assets. The time value of money must also be considered when performing the calculation. All payback values must be expressed in net present value. Simple Payback is not an acceptable method to calculate payback on an investment.

V. Design Temperatures and Humidities

Outdoor Ambient Design Conditions: The following outdoor ambient environmental requirements shall be incorporated into the load calculations, energy modeling and HVAC design:

Heating Season Ambient Outdoor Temperature Design Basis: 0 degrees Fahrenheit

Cooling Season Ambient Outdoor Temperature Design Basis: 95 degrees Fahrenheit dry bulb and 78 degrees Fahrenheit wet bulb

All other climatic information shall be per the ASHRAE Fundamentals Handbook.

Indoor Ambient Design Conditions: The following indoor ambient conditions shall be the design basis and incorporated into load calculations, energy modeling and HVAC design:

Occupied Spaces – Heating: 72 degrees Fahrenheit (dry bulb) and 50%RH in occupied mode and 60 degrees Fahrenheit and 50%RH in unoccupied mode.

Occupied Spaces – Cooling: 75 degrees Fahrenheit (dry bulb) and 50%RH and 85 degrees Fahrenheit and 50%RH in unoccupied mode.

Minimally Occupied Spaces – Heating: 65 degrees Fahrenheit (dry bulb) and 50%RH

Minimally Occupied Spaces – Cooling: 85 degrees Fahrenheit (dry bulb) and 50% RH

Unoccupied Mechanical Spaces – Heating: 55 degrees Fahrenheit (dry bulb)

Unoccupied Mechanical Spaces – Cooling: 85 degrees Fahrenheit (dry bulb)

Unoccupied Spaces Requiring Freeze Protection – Heating; minimum 45 degrees Fahrenheit (dry bulb)

For HVAC system design purposes, assume dormitory spaces are occupied 100% of the time.

Local space temperature overrides can be incorporated into laboratory, clean room and pilot plant spaces only.

A minimally occupied space is defined as a space that is used for purposes that are not intended to be fully occupied or used for assembly. These include but are not limited to stairwells and storage rooms.

An unoccupied mechanical space is defined as a space that houses the equipment and systems that give the building its functionality. These include but are not limited to mechanical rooms, electrical rooms and fire pump rooms. If all possible temperature control of these spaces shall be accomplished with ventilation only. Mechanical cooling shall be used only when ventilation methods cannot maintain set point. If occupied spaces are above or adjacent to mechanical space, ceiling below and wall adjacent to occupied space shall be insulated with a radiant barrier to prevent heat transfer into occupied spaces. **Provide mechanical cooling for any mechanical space containing VFD's or electronics.**

An unoccupied space that requires freeze protection is any unoccupied space that has piping (plumbing, HVAC, sprinkler) in which is at risk for freeze burst if the room space temperature falls below freezing. Freeze protection in these spaces shall be provided via tempering the space temperature via mechanical heating.

VI. Design Basis

Heating and Cooling Districts: Heating and cooling for all new and renovated buildings shall be supplied by the campus heating and cooling districts. In the event that project conditions require that alternative heating and cooling sources should be used, the University of Delaware will entertain other options. Alternative heating and cooling sources must be approved (in writing) by both the University Energy and Engineering Department and the Office of the Campus Architect prior to start of design.

VAV Systems: The base HVAC supply air delivery system for all new and renovated buildings is a forced air system consisting of a variable volume air handling unit and VAV terminals with reheat coils distributed throughout the building. Alternate HVAC systems (for example: chilled beams and underfloor systems) may be considered. Any alternate systems must be evaluated via life cycle cost analysis in reference to the base VAV system to determine viability. Alternate HVAC supply air delivery systems must be approved (in writing) by the University Energy and Engineering Department.

Terminal Heating and Cooling Units: Due to maintenance, IAQ & noise concerns, the use of terminal heating and cooling units such as fan coil units and unit ventilators is restricted to residence hall dormitory rooms only. Written approval is required for use of this equipment in other applications.

VII. Piping Systems

Hydronic Systems: Building level heating and cooling shall be supplied via hydronic systems. Cooling shall be supplied via the chilled water district. Building level chilled water systems shall be de-coupled from the campus supply loop. Heating shall be supplied by hydronic heat exchangers using the steam district as the heating source. All hydronic systems shall be variable flow. Accommodations shall be made to allow for minimum flow through the pumps as per the pump manufacturer's requirements.

Heating Water Temperatures: The design heating water supply temperature is 180 degrees Fahrenheit. Design all heating coils for a 40 degree Fahrenheit temperature drop.

Heating Water Temperature Set Back: A setback schedule for the heating water supply temperature will be established at the start of the project. The engineering design firm will incorporate the setback schedule into their design and calculations.

Chilled Water Temperatures: Chilled water is supplied through the district at 42 degrees Fahrenheit and arrives at the building at a higher temperature. The chilled water arrival temperature is based on where the building is located on campus. Consult with the University Energy and Engineering Department for chilled water entering temperature into the building. Design all cooling coils for a minimum of 14 degree Fahrenheit temperature drop.

Hydronic System Head and Effects on Energy Use: Hydronic pumping is a significant component of the buildings energy consumption. Often times energy consumption is not considered when designing and specifying hydronic systems. Hydronic pumping systems shall be designed with energy efficiency in mind. Pipe routes shall be short as possible and have the minimum amount of bends necessary to deliver the medium. If possible valves and control elements shall be specified with low CV's.

Hydronic Pipe Sizing: Hydronic piping that is undersized often leads to pumping problems, increased energy use and nuisance noises radiated into occupied space. Pipe must be sized as to avoid pumping problems, optimize energy use and eliminate noise generated by excess fluid velocity. The maximum allowable pressure drop through hydronic systems is 2.5ft per 100ft of pipe. The maximum allowable fluid velocity in hydronic systems is 5 gallons per second. There may be times where design constraints require pressure drops and fluid velocities greater than these values. In these instances, the consulting engineer shall consult with UD Energy and Engineering department for directions on how to proceed.

Hydraulic Analysis; It is the responsibility of the consulting engineer to perform a hydraulic analysis on all hydronic systems designed or modified. As part of this analysis the total developed system head shall be calculated. All pipe and pump sizing shall be based on the hydraulic analysis. Pump selections shall not be based on assumed or estimated values.

Pipe Stress Analysis: Dramatic temperature changes and excessive pumping power may cause stress in steam and hydronic heating piping systems. It is the responsibility of the design engineering firm to perform a pipe stress analysis on the steam, condensate and hydronic heating piping systems that they have designed or modified. The design engineering firm shall determine if and where pipe anchors, pipe guides and expansion joints are required based on the pipe stress analysis.

Shut Off Valves: In order to facilitate maintenance of piping systems, shut off valves must be designed into all branch connections. Shut off valves must also be located at all heating and cooling equipment connections. These valves shall be shown on both the system piping diagrams and on the orthographic drawings.

Drain Valves: Drain valves must be located at all low points and at each floor on hydronic piping risers. Drain valves shall be shown on both the system piping diagrams and indicated on the orthographic drawings.

Balancing Valves: Balancing valves must be located at every heating and cooling coil. These valves shall be shown on both the system piping diagrams and indicated on the orthographic drawings.

Air Vents: Air vents must be located at all high points in the hydronic piping systems. Air vents shall be shown on both the system piping diagrams and indicated on the orthographic drawings.

Gauges and Thermometers: In order to diagnosis hydronic problems, gages and thermometers must be located on at the following areas:

A. Suction and Discharge of chilled water and hydronic heating pumps
B. Inlet and Outlet of cooling, heating & energy recovery coils
C. Inlet and Outlet of hydronic heat exchangers

Gauges and thermometers must be located on both the system piping diagrams and on the orthographic drawings.

Underground Piping: If modifications to the campus loop is required, the consulting engineer shall design the modifications. The consulting engineer is responsible for the entire design including all civil work, manhole design, anti-buoyancy measures and pipe stress remediation.

Freeze Pumps: On 100% outside air units, freeze pumps shall be used at the pre-heat coils to prevent coil freeze burst. The freeze pumps shall be on emergency power. Freeze pumps shall be engaged when called for by a signal from the freezestat. Freeze pumps shall not be used to provide supplemental pumping.

Pipe Routes: If all possible, route hydronic piping through corridors, open areas, and service areas only. Do not use laboratories, process areas, dormitory residence rooms, class rooms, lecture halls or conference rooms as pass throughs for hydronic piping. Only route hydronic piping into laboratories and process areas if it is required to service equipment or processes in the laboratory/process areas. Only route hydronic piping into class rooms, lecture halls and conference rooms that are required for heating equipment in these spaces. Do not route hydronic piping through electrical rooms, elevator machine rooms, telecommunication rooms, or computer/server rooms.

VIII. Air Systems

Static Pressure Calculations: It is the responsibility of the consulting engineer to perform a static pressure drop analysis on all ducted systems designed or modified. As part of this analysis the total system static pressure shall be calculated. All fan and air handling unit sizing shall be based on the static pressure drop analysis. Fan and air handling unit selections shall not be based on assumed or estimated values.

A. Supply & Return Air Distribution Systems

System Static Pressure: Fan based air delivery systems often are significant sources of campus energy consumption. System static pressure losses often drives the energy consumption associated with air delivery systems. The consulting engineer is responsible for minimizing system static pressure losses. Supply air distribution systems shall be designed for a maximum static pressure drop of 0.10 inches per 100ft. Duct runs should be as short as possible. High-loss fittings such as mitered elbows, abrupt transitions, abrupt take-offs and internal obstructions shall be avoided. System static pressure calculations shall be revisited during shop drawing review to determine the final system static pressure. Consulting engineer shall determine if modifications to the air system are required based on final static pressure calculations.

Duct Design: Air distribution systems shall be designed as per SMACNA HVAC Systems Design Manual and ASHRAE Fundamentals.

Duct Aspect Ratio: The aspect ratio (ratio of width to height) of rectangular ducts should be minimized to reduce pressure losses. Duct aspect ratio shall not exceed 4:1.

Duct Velocities: Excessive air velocity through duct will cause unnecessary energy losses and excessive air noise. The air velocity through supply air distribution systems shall not exceed the following values:

A. **Duct Mains in Mechanical or Unoccupied Spaces:** not to exceed 1500fpm
B. Duct Mains through Occupied Spaces: not to exceed 1000fpm
C. Branch Duct from Main to VAV Terminal: not to exceed 1000fpm
D. Branch Duct from VAV Terminals to Outlets: not to exceed 500fpm

Intake Louvers: Excessive air velocity through intake louvers will draw moisture and rain into the building and may cause indoor air quality issues. The face velocity of intake louvers shall not exceed 750fpm across the free area. Care must be taken when locating intake louvers. The consulting engineer is responsible for locating intake louvers so that airborne contaminants either from the external environment or from building exhaust are not introduced into the building. Intake louvers shall be located no less than 12” above grade.

Terminal Outlet Velocity: High terminal outlet velocities often leads to occupants perceiving that the space is colder or warmer than it actually is and results in nuisance calls. The terminal velocity of discharged air 24 inches from wall surfaces should be less than 50 FPM at 6 feet above floor height.

Air Handling Units: Generally air handling units consist of a fan, heating and cooling coils, filters and a mixing box. A properly designed air handling unit is necessary to achieve energy efficiency, maintain building comfort and to insure the safety and health of the occupants. Excessive air velocities through the air handling unit compromises these goals. Chilled water coil face velocities shall not exceed 400fpm. Heating water coil face velocities must not exceed 750fpm. Filter face velocities shall not exceed 500fpm.

Air handling unit design discharge air temperature is 55 degrees Fahrenheit.

Often poor field conditions result in air handling units underperforming in relation to submitted data. Abrupt transitions, tees and elbows on the discharge and intake of the air handling units often cause turbulent flow through the air handler. This turbulent flow compromises the performance of the fan and the heat transfer coils. Supply air systems shall be designed so that the air handling unit can perform as per the manufacturer's submitted performance. The engineer shall allow for proper distances between the air handling unit inlet/outlet and any elbows or tees. All transitions shall have a maximum rake angle of 30 degrees.

Air Inlet and Outlet Terminals: Air terminals shall be selected to provide a uniform, quiet and low – velocity distribution covering the majority of the occupied area, Air terminals shall not dump the air, create drafts or generate turbulence within the rooms. In order to minimize sound radiating into occupied spaces, all air inlet and outlet terminals shall have a maximum NC rating of 30.

Laminar flow air diffusers shall be used in spaces where turbulent air can disrupt critical operations. These spaces may include but are not limited to laboratories, vivariums and pilot plants.

Balancing Dampers: Balancing dampers shall be designed into each branch take-off and into each outlet terminal. These dampers shall be shown on both the system piping diagrams and on the orthographic drawings.

Return Duct vs Return Air Plenums: The decision to use return duct or return air plenums is complex and is based many variables including the buildings use, envelope and geometry. This decision will be made on case by case basis. The University of Delaware shall be included in the decision to use either a ducted return or a return plenum.

B. Exhaust Air Systems

System Static Pressure: Fan based air delivery systems often are significant sources of campus energy consumption. System static pressure losses often drives the energy consumption associated with air delivery systems. The consulting engineer is responsible for minimizing system static pressure losses. Duct runs should be as short as possible. High-loss fittings such as mitered elbows, abrupt transitions, abrupt take-offs and internal obstructions shall be avoided.

Duct Design: Air distribution systems shall be designed as per ACGIH Industrial Ventilation Manual, SMACNA HVAC Systems Design Manual and ASHRAE Fundamentals.

Duct Aspect Ratio: The aspect ratio (ratio of width to height) of rectangular ducts should be minimized to reduce pressure losses. Duct aspect ratio shall not exceed 4:1.

Duct Velocities: In order to effectively remove contaminants from environments it is often necessary for air velocities in exhaust systems to be higher than in supply air systems. The air velocity through exhaust ducts often depends on variables such as the toxicity, corrosiveness and particle size of the materials captured in the exhaust system. The design engineer must consult with end users to determine what contaminants are to be captured by the exhaust system. The consulting engineer should consult the most recent edition of the ACGIH Industrial Ventilation Manual to determine the adequate air velocity required for the exhaust duct system. Duct velocities shall be kept to the minimum to reduce energy and operations cost.

General bathroom exhaust can follow the duct velocities recommendations in the supply and return air distribution systems section.

Exhaust Duct Materials: Often times due to the nature of what is conveyed in the exhaust system, exhaust ducts are subject to corrosion. It is the responsibility of the consulting engineer to choose materials of construction that will not corrode due to reactions with any substances traveling through the exhaust system.

Point Source Capture of Contaminants: Often in the past a blanket air exchange rate was used to determine the exhaust ventilation of laboratory and pilot plant spaces. This air changes per hour method provided a false sense of security while driving up energy consumption rates. The modern method is to capture contaminants at the point source. It is the responsibility of the consulting engineer to determine the sources of the contaminant and the method of capture.

Point source capture face velocities shall not exceed the following:

A. **Laboratory Fume Hoods:** Occupied 100fpm, Unoccupied 60fpm
B. **Ventilated Enclosures:** Occupied 100fpm, Unoccupied 60fpm
C. **Biological Safety Cabinets:** 100 fpm
D. **Canopy Hoods:** Occupied 100fpm, Unoccupied 60fpm
E. **Slot Hoods:** Occupied 100fpm, Unoccupied 60fpm
F. **Elephant Trunks:** 60fpm
G. **Fume Extractor Arm:** Per manufacturer’s recommendations

Canopy Hoods: The use of canopy hoods must be approved by engineering services.

Exhaust Fans: Often poor field conditions result in exhaust fans underperforming in relation to submitted data. Abrupt transitions, tees and elbows on the discharge and intake of the exhaust fans often cause turbulent flow through the exhaust fan. This turbulent flow compromises the performance of the fan. Exhaust air systems shall be designed so that the exhaust fan can perform as per the manufacturer’s submitted performance. The consulting engineer shall allow for proper distances between the exhaust fan suction/discharge and any elbows or tees.

Exhaust Louvers: The face velocity of intake louvers shall not exceed 1000fpm across the free area. Care must be taken when locating exhaust louvers. The consulting engineer is responsible for locating exhaust louvers the required distance away from intake louvers, operable windows and doors.

Exhaust Stacks: Exhaust stacks shall be designed so that the outlet is no less than 10’-0” above the roof surface and 3’-0” away from any adjacent roof or wall structure.

Kitchen Exhaust: Kitchen exhaust systems shall comply with NFPA 69.

C. Duct Routes

Duct Routes: If all possible, route duct through corridors, open areas, and service areas only. Do not use laboratories, process areas, class rooms, dormitory residence rooms, lecture halls or conference rooms as pass throughs for ducts. Only route ducts into laboratories and process areas if it is required for these spaces. Only route ducts into class rooms, lecture halls and conference rooms that are required for these spaces. Do not route ducts through electrical rooms, elevator machine rooms, telecommunication rooms, or computer/server rooms unless they are required for these spaces.

IX Noise Attenuation

The use of lined duct for sound attenuation is prohibited. The preferred method of noise control for HVAC systems is a good duct design. If HVAC noise cannot be managed using good duct design practices, sound attenuators may be designed into the HVAC system. Sound attenuators shall be selected to minimize pressure losses in the duct system. Sound attenuators shall not be the default method for noise control in HVAC systems.

X. Ventilation and Indoor Air Quality

Indoor Air Quality: The consulting engineer shares in the responsibility of insuring the quality of the air inside of its scope of work. The consulting engineer must incorporate both contaminant and odor control within the design. All HVAC systems shall have sufficient filtration to remove contaminants from the air stream. In addition spaces that are known odor sources such as janitor's closets, kitchenettes and break rooms shall be exhausted.

Ventilation: Engineering firm shall use ASHRAE 62.1 as the basis to establish minimum ventilation rates for general administrative and educational spaces. The University of Delaware has a preference for demand control ventilation of these types of spaces. If possible and practical, demand control ventilation shall be incorporated into the HVAC system.

Laboratories: Due to their nature, laboratories shall use 100% outside air to provide ventilation. HVAC systems shall not return air from laboratory spaces.

Vivariums: The consulting engineer shall consult with the vivarium manager for ventilation requirements of the vivarium.

Humidity and Moisture Control: The consulting engineer shall assist in the elimination of humidity and moisture from newly designed or renovated buildings. The HVAC design shall include all necessary humidity and moisture control measures.

XI. Building Pressurization

Envelope Pressurization: Buildings shall be positively pressured to +0.01" in relation to the external environment.

Classroom: In general classrooms shall be neutral to the surrounding areas.

Offices: Offices shall be neutral to the surrounding areas

Laboratories: Laboratories shall be negatively pressured to -0.1" in relation to the surrounding areas

Vivariums: The consulting engineer shall consult with the vivarium manager for pressurization requirements of the vivarium.

Clean Rooms: Clean rooms in general are positively pressures in relation to its surrounding areas. The consulting engineer shall consult with the clean room manager to determine the level of pressurization.

Rest Rooms and Shower Rooms: Rest rooms and shower rooms are negatively pressures to -0.05" in relation to the surrounding areas.

Janitors Closets Janitor's Closets are negatively pressures to -0.05" in relation to the surrounding areas.

Kitchenettes and Break Rooms Kitchenettes and Break rooms are negatively pressures to -0.05" in relation to the surrounding areas.

Stairwell Pressurization: Stairwells and stair towers shall be pressurized as per all related safety codes.

XII. Energy Efficiency & Conservation

Engineering firm shall use ASHRAE Standard 90.1 as the basis to establish minimum energy efficiency requirements. It is the responsibility of the HVAC engineer to design the most efficient HVAC system that conforms to the life cycle cost analysis. These measures listed below are the minimum University of Delaware requirements:

Economization: When outdoor conditions are appropriate, HVAC systems shall engage an economization cycle to provide free cooling or tempering. Economization shall be employed to provide free cooling in both occupied and unoccupied spaces. Differential enthalpy economization is the only method of economization allowed.

Demand Control Ventilation: Demand control ventilation shall be applied where applicable.

Energy Recovery: Energy recovery shall be applied where applicable. The University of Delaware has a preference for refrigerant based energy recovery systems. UD will also consider glycol based run around loops and energy recovery hydronic heat exchangers. Energy recovery wheels and air to air heat exchangers are not allowed at the Newark Campus.

Refrigerant based energy recovery systems shall operate in both heating and cooling.

XIII. Building Automation Systems (BAS)

The Tri-M Group LLC is the term contractor for building automation systems for the University of Delaware's Newark Campus. The HVAC design engineer shall contact The Tri-M Group (1-610-444-1002) at the start of the project. The Tri-M Group shall consult and assist with the development of BAS sequence of operations, point list and BAS specifications.

XIV. Maintenance Considerations

A properly designed HVAC system will incorporate maintenance measures into the design. The following are the minimum requirements for system maintainability:

Floor Mounted Equipment: All floor mounted equipment shall be located on a minimum 6" high housekeeping pads:

Roof Mounted Equipment: All roof mounted equipment shall be located on a structural steel platform that is a minimum of 24" above the roof. The platform shall have stair access and hand rail that complies with OSHA safety regulations. The platform shall have a 36" access way on all sides of the equipment.

Ceiling Mounted Equipment: Any equipment mounted above ceilings shall be located so that the bottom and accessible sides shall be clear of any obstructions.

Maintenance Clearances: A 36" minimum maintenance access area must be maintained around all pieces of equipment. Service corridors shall be designed into all mechanical spaces so that equipment can be moved through the space and out of the building. The consulting engineer is required to demonstrate that all equipment is accessible, maintainable and can be moved through the mechanical space and out of the building.

Air Handling Units: Clearances around air handling units must accommodate removal and replacement of all coils. Access to access doors must not be inhibited.

Heat Exchangers: Heat exchangers shall be arranged to provide adequate system head for condensate removal. Clearances around heat exchangers must accommodate removal and replacement of tube bundles.

Valves: Valves must be arranged so that they may be operated in a safe matter. In general valve handles shall be operated without hindrance. The maximum allowable height for any valve handle is 10'-0" from finished floor. Valves shall be located so that they may be replaced without removing any other element in the mechanical room.

Gauges and Thermometers: Gauges and thermometers shall be located so that they can be accessed without a ladder. Nothing shall be located in front of gauges or thermometers.

Steam Specialties: Steam specialties (Relief Valves, PRV's, Traps) shall have a minimum 36" clearance work space and shall be designed to be easily removed.

Dampers: Damper must be clear of any obstructions and shall be located as to provide adequate clearance for access.

In Line Instrumentation: Access to inline instrumentation shall be clear of obstructions. If possible, inline instrumentation shall be located no more than 8'-0" off of finished floor.

Exterior Pipes and Ducts: Avoid routing pipes and ducts exterior to buildings. If all possible find routes within the building. Consult with the University Energy and Engineering Department if pipe and duct routing exterior to the building is determined to be unavoidable. If determined unavoidable routes shall be kept to a minimum. Exterior pipes and ducts on historical buildings and on buildings facing the green is not allowed.

Exposed Piping and Duct: Avoid routing exposed pipes and ducts in occupied spaces. Exposed pipes and ducts in historical buildings is not allowed. Consult with the University Energy and Engineering Department if exposed pipes and ducts in occupied spaces is unavoidable.

Lifting Beams: Provide lifting beams where needed to service heavy equipment such as heat exchangers, large pumps, large fans, large motors….etc. Lifting beams must be designed by a structural engineer and meet all OSHA and ASME requirements.

XV. Engineering Surveys

The consulting engineer must not base its design only on documentation provided by the University. The consulting engineer must conduct a thorough engineering survey of the spaces and systems modified prior to the start of the design. All field conditions and modifications affecting the design shall be incorporated into the design. It is the responsibility of the engineering firm to determine what University of Delaware personnel (engineer, shop manager, field mechanic…etc.) will be required during the survey. All personnel support shall be scheduled a minimum two weeks in advance.

XVI. Standards

The consulting engineer is responsibility for incorporating all requirements detailed in the University of Delaware HVAC standards into the design.

XVI. Room & Equipment Data Sheets

The consulting engineer shall assist architect with room and equipment data sheets. The consulting engineer shall help determine temperature, humidity and exhaust requirements for spaces and equipment.

XVII. Schedule of Deliverables

In order to facilitate a holistic approach to University of Delaware design projects, the University requires multiple submissions of documents. The purpose of these submissions is to provide a framework in which the consulting engineer is in regular communication with the University of Delaware project team. This communication may be via a combination of meetings and e-mail submissions with teleconferences. This will be decided by the University of Delaware project team on a project by project basis.

The following is a list of deliverables required by the University of Delaware. The deliverables are listed as to when to present them to the University of Delaware.

Programming:
Load Calculations/Energy Analysis/Life Cycle Cost Analysis – Engineering firm shall document in report form data used to perform calculations and the findings of the analysis.
Code Requirement Analysis for MEP Design – Engineering firm shall document in report form all code requirements that impact the design of the HVAC system.
Analysis of effects on Campus Steam & Chilled Water Districts – Engineering firm shall document the effects of HVAC system has on the campus distribution systems.
Basis of Design Document

Schematic Design Submission 1:
HVAC Zoning Maps – HVAC zoning maps shall indicate which rooms are served by which HVAC equipment. This shall include all HVAC equipment, including but not limited to, air handling units, VAV terminals and exhaust air valves. HVAC Zoning Maps shall indicate location of thermostats.
HVAC Zoning Tabulations – In spreadsheet form, HVAC engineering firm shall tabulate demand on each VAV terminal. The spreadsheet shall include minimum and maximum air flow rates, heating water flow rates, heating loads and cooling loads. Spreadsheet shall total the data from VAV's to the corresponding air handling units. Air handling unit tabulation shall contain minimum and maximum chilled and heating water flow rates.
HVAC Space Pressure Diagrams – The HVAC Space Pressure Diagrams shall document in orthographic form the pressure relationship between adjacent spaces within the building and the building to external environment.
Airflow Diagram – Airflow diagrams shall indicate all duct sizes, transitions, equipment, inlet and outlet terminals, airflows through equipment and terminals, dampers and inline instrumentation
Steam, Chilled Water & Heating Water Piping Diagrams - **Piping** diagrams shall include all pipe sizes, transitions, equipment, valves and inline instrumentation.
Building Smoke Control Scheme (If Required) - A description in both narrative and diagrammatic form of how smoke will be managed in the building.

Schematic Design Submission 2:
Building Automation System (BAS) Diagrams
BAS Points List
BAS Sequences of Operation
Mechanical Space Block Diagrams (Mech Rooms/Elec Rooms & Roof) – All major equipment shown in plan as blocks that represent size and geography of the equipment. Maintenance clearances are dimensioned around the equipment. Coil and tube bundle pull areas are indicated on the drawing. This diagram will be used to develop mechanical space layout and size.
First Pass Duct Static Pressure Calculations
First Pass Hydraulic Head Calculations – Mechanical Piping Systems
External Wall Penetrations Identified & Located (Provide Detail of Wall Penetrations for Review)
Fire & Smoke Dampers Identified and Located

Design Development Submission 1:
HVAC Equipment Schedules in Spreadsheet Format
HVAC Equipment Data Sheets and Specifications

Details Mechanical Space Layouts (Mechanical Rooms & Roof)
Mechanical Shaft Located & Layouts
Single Line HVAC Plans
Single Line Mechanical Piping Plans
BAS Specification
Testing & Balancing Specification

Design Development Submission 2:
Pipe Stress Flexibility Analysis Completed – Anchors, Guides, Flex Joints and Expansion Joints Identified)
Detailed Duct Static Pressure Calculations
Detailed Hydraulic Head Calculations
Mechanical Systems Single Line Mechanical Piping Plans
Duct Material Schedule including pressure classifications for each piped system
Pipe Material Schedule including pressure classifications for each piped system
Pipe and Duct Insulation Material Schedule
Material Specifications for piping, valves, ducts, hydronics specialties, air specialties , GRD's, Louvers and Insulation
HVAC Detail Sheets

Design Development Submission 3
Lead Sheet including Legends
Detailed Double Line Ductwork Plans
Detail Piping Plans. Piping sizes greater than 2" diameter shown in double line
HVAC Elevations and Sections
HVAC Schedule Sheets
HVAC General & Construction Specifications
HVAC Construction Scopes of Work

Construction Documents:
Full Set of Construction Documents – Issued for Bid (This shall include final version of all drawings, diagrams, specifications and scopes of work issued in previous submissions)
Final Version of all Calculations and Reports Issued in Previous Submissions

End of Section